Chemiresistor Vapor Sensor Array Employing Monolayer-Encapsulated Metal (MenM) Nanoclusters

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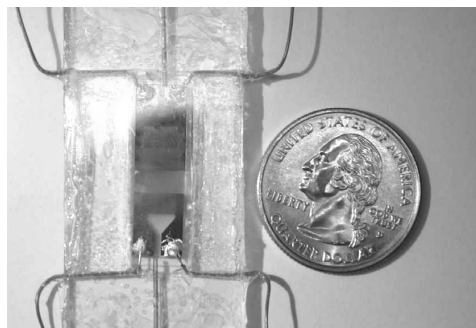Ann Arbor, MI 48109-2029(ezellers@umich.edu)

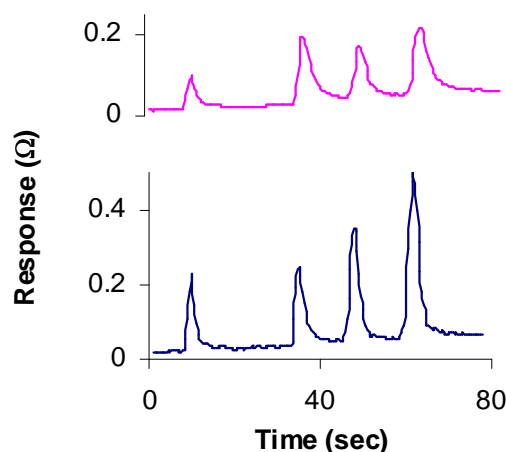Figure 1. Dual-chemiresistor array detector

Figure 2. GC-elution profiles of, in order, toluene, butyl acetate, chlorobenzene, and m-xylene from a dual-chemiresistor array with coatings of Au-benzeneethanethiol (upper) and Au-octanethiol (lower).

Nanoclusters comprising Au, or other metal, cores with peripherally-bound self-assembled thiolate moieties exhibit unique electronic and electrochemical properties.[1,2] Wohltjen and Snow recently reported preliminary results on one such material as a chemically sensitive layer of a chemiresistor vapor sensor.[3] Electronic conduction in films of these materials occurs by electron tunneling or hopping mechanisms and is reduced upon vapor sorption due to swelling of the thiolate surface layers. In this work, two Au MenM nanoclusters were synthesized and tested as chemically sensitive interfaces on chemiresistors. Thin layers of Au-octanethiol and Au-benzeneethanethiol nanoclusters were spray-coated on chemiresistors having 50 pairs of gold electrodes, which were then exposed to vapors of acetone, n-butyl acetate, 1,4-dioxane, isooctane, methyl ethyl ketone, perchloroethylene, chlorobenzene, toluene, and m-xylene. The change in dc-resistance varied linearly with vapor concentration from 40-400 ppm and limits of detection in the low-ppm range were achieved; about an order of magnitude lower than achieved with polymer-coated surface-acoustic-wave (SAW) sensors. Response times were ~3 sec and responses were reproducible (rsd < 2%). Unique response patterns were obtained for all vapors.

To further test this dual-sensor array, it was packaged in a glass detector cell and incorporated into a system consisting of an adsorbent preconcentrator and a GC-column for vapor mixture analysis. 0.5-L samples of a 4-vapor mixture were preconcentrated on a 2-mg bed of a novel 50-μm-diameter graphitized carbon adsorbent and thermally desorbed at 300 °C. Peaks eluting from the 30-m GC column were sharp (width at half-max. = 1-3 s) and maxima increased linearly with concentration from 20 ppb to 200 ppb. Calculated LODs ranged from 0.7 ppb (m-xylene/Au-octanthiol) to 3.6 ppb (toluene/Au-benzeneethanethiol). These preliminary results demonstrate the utility of MenM nanoclusters as chemiresister sensor array coatings. Additional data will be presented.

References

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2. R.S.Ingram and R.W.Murray, Electroactive three-dimensional monolayers: anthraquinone - functionalized alkanethiolate-stabilized gold clusters, Langmuir, 1998, 14, 4115 –4121.
3. H.Wohltjen and A.W.Snow, Colloidal metal-insulator-metal ensemble chemiresistor sensor, Anal. Chem., 1998, 70, 2856-2859.